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School Science

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THE HEURISTIC METHOD OF TEACHING*.

BY HENRY E. ARMSTRONG.

"New times demand new measures and new men;
The world advances, and in time outgrows
The laws that in our fathers' days were best;
And, doubtless, after us some purer scheme
Will be shaped out by wiser men than we
Made wiser by the steady growth of truth."
*　*　*　*　*
"Our time is one that calls for earnest deeds."
(LOWELL.)

All who seriously study the history of education in our times must agree that, although it may be long ere we can cry *Eureka! Eureka!* of an ideally perfect system, recent experience justifies the assertion that we shall hasten the advent of that desirable time if we seek to minimize the didactic and encourage heuristic teaching; for the progress made of late, which is very considerable, is unquestionably due to the introduction of heuristic methods and exercises.

But many will ask—what are heuristic methods? Even the word is strange to us, they will add.

True it is not yet in the dictionary; but it is scarcely possible to doubt that it is come to stay, and will—nay, must—soon be there; indeed, its introduction as the watchword of a party seems really to meet a want.

* Parts of a Report to the Board of Education of England.

Heuristic methods of teaching are methods which involve our placing students as far as possible in the attitude of the discoverer—methods which involve their *finding out*, instead of being merely told about things. It should not be necessary to justify such a policy in education. Unfortunately, however, our conceptions are blunted by early training, or rather by want of training. Few realize that neither is discovery limited to those who explore Dark Continents or Polar Regions, nor to those who seek to unravel the wonders of Nature; that invention is not confined to those who take out patents for new devices; but that, on the contrary, discovery and invention are divine prerogatives, in some degree granted to all, meet for daily usage, and that it is consequently of importance that we be taught the rules of the game of discovery and learn to play it skillfully. The value of mere knowledge is immensely over-rated, and its possession over-praised and over-rewarded; action, although appreciated when its effects are noted, is treated as the outcome of innate faculties, and the extent to which it can be developed by teaching scarcely considered.

Professor Meiklejohn contends that the permanent and universal condition of all *method* in education is that it be heuristic; and goes on to say:

"This view has its historic side; and it will be found that the best way, the truest method, that the individual can follow is the path of research that has been taken and followed by whole races in past times. This has, perhaps, been best put by Edmund Burke, probably the greatest constructive thinker that ever lived in this country. He says: 'I am convinced that the method of teaching which approaches most nearly to the methods of investigation is incomparably the best; since not content with serving up a few barren and lifeless truths, it leads to the stock on which they grew; it tends to set the learner himself on the track of invention, and to direct him into those paths in which the author has made his own discoveries.' It may be said, Professor Meikeljohn continues, that this statement is applicable to science and to science only." But I am prepared to show at the right time that it is applicable to literature also, though not in the fullest extent and application of the method. The heuristic method is the *only* method to be

applied in the pure sciences; it is the best method in the teaching of the applied sciences; and as it is *a* method in the study of those great works of art in language by the greatest minds which go by the general name of literature.

It would be easy to support this contention by numerous other quotations, but one will suffice—than which, however, none could be more impressive or striking. I refer to the words used by Lessing: "If the Almighty were in the one hand to offer me Truth, and in the other the Search after Truth, I would humbly but firmly choose the Search after Truth."

I can clearly trace the development of my heuristic tendencies —which are certainly in a large measure innate, for my father was critical and enquiring—to one of my school books—absolutely the only interesting one that came into my hands—to a literary work, *Trench's Study of Words;* and can well recollect how this book at once fascinated me—and not me alone, but my father also, a commercial man, whose early training and career had been such as to leave him entirely unacquainted with subjects of the kind. I still vividly recall to mind how from this book, as a mere lad, I for the first time gained ideas as to the value of method—of what I should nôw call *scientific method.* It even taught me to appreciate Euclid, the deadly dullness of which subject long oppressed me, as it does probably almost every boy or girl at school, for there was no meaning apparent in it as it was presented; it seemed in no way to connect itself up with any experience I had gained; but somehow, after reading Trench, the scales suddenly fell from my eyes, its logical character at least became evident, and it was no longer so difficult to understand or to master—but I cannot say that it ever became interesting or its use obvious. This experience has haunted me through life, and has often led me to think how much I might have learned at school had I been properly taught, or even provided with a few books giving insight into method, like Trench's; I owe to it more than to anything else the growth of a desire to promote the teaching of method.

As a student of science I was equally perverse. I had every desire to learn, but didactic teaching seemed always to produce

a sense of irritation. Practical work was intensely interesting, although it was only too often done in obedience to orders without the underlying philosophical motive being clear. The facts recited in the lecture room, especially when accompanied by experimental illustrations, frequently came as revelations, but, on the whole, listening to lectures produced little abiding effect, one image following the other too quickly. Text books I always found unattractive and unsatisfying—often nauseating, for I felt that I wanted to become a chemical cook myself, not merely to know what the dishes were made of and what they looked like on the table; however, I got through them and the measles lightly, without any serious disturbance of mental balance, such as a hard fate, and unreflecting educators, impose on most students who are forced, by the pressure of examinations, to unduly indulge in food so indigestible and unpalatable. Happily the proper corrective was soon discovered; for, being an omnivorous reader, it was my good fortune, at an early stage, to have my attention called to original literature. Needless to say, this proved to be intensely interesting, as glimpses of method were soon gained from it. Full emancipation came later—the haven being reached when I passed from the mainly didactic surroundings of an English laboratory into the heuristic atmosphere of a German university. I seemed to escape into an Elysium.

Nevertheless, in the course of years, I had been insensibly compelled to swallow much poison, and this had its inevitable effect. Impressed habits and convictions were not easily cast aside; so that, when I started my career as a teacher, although I saw much reason to be dissatisfied with existing practices, it was only very gradually that I could divest myself of conventional articles of belief, or make up my mind what changes were necessary and feasible. Therefore I can always fully sympathize with teachers whose convictions have been forced upon them—whose peace of mind was until recently undisturbed. It is easy to understand that it will be very difficult for them to enter fully into the spirit of the heuristic doctrines that are now being widely preached, and still more so for them to apply methods which they have never previously been trained to understand.

It must from the outset and ever be remembered that the great object in view in education is to develop the power of initiative, and in all respects to form the character of the pupil. The appreciation of this contention is crucial. "The pious Pestalozzi is filled with measureless remorse when he finds that he has *given* a little boy a conception, instead of inducing him to find it himself," remarks Professor Meiklejohn. So should every teacher be; and if the feeling expressed in this sentence can but be made to rankle in the mind of every teacher, the end is achieved. Schools will then become educating institutions; the didactic instruction which poisons our existence at the present day will be properly recognized as a fell disease.

It is necessary to insist on this over and over again, as even among those who are becoming advocates of heuristic training there is often incomplete recognition of the fundamental importance of observing such an attitude towards learners. The following passage for example, occurs in the chapter headed "Physical Science" in Spencer's *Aims and Practice of Teaching Physical Science* (London, 1897, C. J. Clay & Sons), to which I have contributed the chapter on chemistry.

"A great deal has been written in favor of the research attitude on the part of the learner. But despite the force of some of the arguments adduced, it may be doubted whether this attitude is the proper one for a beginner. At the commencement of a science course the teaching cannot be too simple, and it must be very clear and definite. Each step taken should logically follow from the work already done, and every experiment should be undertaken with a definite object, which should be fully understood and appreciated by the class. In working out a course of this kind, the *teacher* might, with advantage, follow an imaginary research path into the subject, but the scholars may not become conscious of this, and it is quite unnecessary that they should. If scholars are taught to observe the progress of an experiment in a vague sort of way, and asked to deduce results from their observations, without being told definitely what to look for and how to look for it, the only result of the work is waste of time. In fact, until the scholars have acquired a little knowledge of the subject, it is useless to expect them to reason for themselves in the way necessary to follow out even the simplest research. Reasoning of this kind involves a knowledge of the facts and

principles of the subjects, and a beginner's time is best employed in acquiring this knowledge under the guidance of a competent teacher!"

This presentment of the question may appeal to some who are not versed in the work. It is no question, however, of force of arguments adduced, but one of facts established, and of experience gained in practice among scholars of every type. It is in no sense mere opinion on my part, but a conviction gradually forced upon me and established beyond all doubt by actual trial and observation during many years past, that the beginner not only may but must be put absolutely in the position of an original discoverer; and all who properly study the question practically are coming to the same opinion, I find. Young children are delighted to be so regarded; to be told that they are to act as a band of young detectives. For example, in studying the rusting of iron, they at once fall in with the idea that a crime, as it were, is committed when the valuable, strong iron is changed into useless, brittle rust, and with the greatest interest set about finding out whether it is a case of murder or of suicide, as it were—whether something outside the iron is concerned in the change, or whether it changes of its own accord.

It is of no use for the teacher merely to follow an imaginary research path; the object must ever be to train children to work out problems themselves, and to acquire the utmost facility in doing so. Of course, the problems must be carefully graduated to the powers of the scholars, and they must be insensibly led; but do not let us spoil them by telling them definitely in advance what to look for and how to look for it; such action is simply criminal.

My experience teaches me also that it is the grossest libel on young scholars to say that it is useless to expect them to reason for themselves in the way necessary to follow out the simplest research; but, unfortunately, if you substitute teachers for scholars this is too often a true statement, and here the supreme difficulty of properly carrying out heuristic teaching comes in. It is the teachers who are preventing advance. Let us teachers recognize this; but do not let us overwork and misrate the powers of young children.

Let us try what we can do, and if we do not at first succeed, let us try and try again; we shall surely succeed if we can only adopt this attitude. But, if we fail, let us give up the work as soon as possible, and leave it to others to succeed where we have failed. No other policy is an honest one—for the teaching of young children should never be regarded as a perfunctory task, but as a sacred office. The whole policy of the teacher's duty is summed up in one little word, yet the most expressive in the English language: it is to train pupils to do. On this it is easy to base a simple test of competency.

It is needless to say young scholars cannot be expected to find out everything themselves; but the facts must always be so presented to them that the process by which results are obtained is made sufficiently clear, as well as the methods by which any conclusions based on the facts are deduced. And before didactic teaching is entered upon to any considerable extent, a thorough course of heuristic training must have been gone through in order that a full understanding of the method may have been arrived at, and the power of using it acquired; scientific habits of mind, scientific ways of working, must become ingrained habits from which it is impossible to escape. As a necessary corollary, subjects must be taught in such an order that those which can be treated heuristically shall be mainly attended to in the first instance.

PROFESSOR MORLEY ON THE TEACHING OF CHEMISTRY.

BY LYMAN C. NEWELL.

At a recent meeting of secondary school teachers, Professor Edward W. Morley, of Western Reserve University, made some remarks on "The Teaching of Chemistry." As far as the writer knows, this paper has been published in only one magazine, and

this magazine is not usually read by secondary school teachers. The limited circulation of Professor Morley's views on this subject, as well as his reputation as a teacher of chemistry, a scholar and an investigator, have induced the writer to present portions of this paper to the readers of SCHOOL SCIENCE.*

Speaking of one unfortunate result of immaturity, Professor Morley says:

"I want also to mention a difficulty which affects our teaching, and which comes from the immaturity of many of our teachers. It affects the teaching of science more than it affects the teaching of Latin or Greek or mathematics, for reasons which I shall state later. That immaturity is commonly shown in the fact that the teacher is more interested in the science itself than in the use of the science as an instrument of education, and he therefore at times tends to emphasize those matters or relations which interest himself, rather than to select for his scholars those things which are best fitted for their use at their stage of progress.

"I had in my hands a few years ago a syllabus of a short course of lectures in a university extension course upon chemistry. In the first lecture the lecturer gave three axioms of physics. Why he should have put these into a course of six lectures on chemistry was not plain to me. Then he went on to give what he said were three corresponding axioms in chemistry, and I supposed that there we should certainly have three important and established principles, selected as being especially adapted to a beginner. But one axiom read as folows: 'Every element can be transformed into any other element. Many scientific men do not accept this axiom.' Well, a proposition which not many scientific men believe to be true could be put in front of one's elementary teaching only in consequence of immaturity of judgment. One might as well begin teaching a child his letters with a discussion of the share of Cadmus in inventing the alphabet. This example of the evils which come from immaturity in the teacher may well be an extreme case, but a lesser degree of the

*It should perhaps be mentioned that Professor Morley has revised his remarks for SCHOOL SCIENCE, which will account for their different version in the JOURNAL OF PEDAGOGY, in which the complete paper was published.

same selection of matters which interest the teacher fresh from a year of graduate study, but which are not suited to the needs of the student, are not uncommon. We teach the electrolytic dissociation hypothesis to students who ought to spend the time in learning the relation of acids, bases and salts; or the periodic law to those who ought rather to consider the difference between rapid and slow combustion. The good teacher may well be interested in the periodic law, or in dissociation into ions, with a more immediate and vivid interest, but unless he can also retain a deep interest in combustion and neutralization and the properties of sulphur, for the sake of the pupils under him, he needs to get his bearings anew. It is well that a carpenter should attend evening schools in wood carving, but ill that he should use his carving tools and neglect his planes and chisels next day in making me a door."

His views on the inductive method may be judged by the following:

"The teacher should cultivate soundness of judgment as to what is possible with classes which he instructs. I read the other day some laboratory directions which said that the student should make the experiment, and then make his inference, without being told what to look for. Well, some great men have advanced science by finding the unexpected and the unlooked for—that of which they had no previous hint. But is it possible to find in a class of forty, some thirty-five who can do anything like that? We do well if, having told the student what is the nature of the problem and the method of solving it, we can get him accurately to understand both, and then, after the manipulation is finished, to write an intelligent and adequate statement of the course of thought involved. Not many succeed triumphantly even, when working in this way, they have been led to formulate a definite question which can be answered by yes or no. I give a student a bottle of sulphuric acid and a bottle of solution of litmus, and tell him to find one of the properties of an acid. After a moment's thought he writes: 'A. To determine some of the properties of an acid. B. By acting on litmus with sulphuric acid.' Seeing that

he has thought out the nature of the problem and the method of its solution, I leave him for a few minutes, and return to find that he has written as follows: 'C. Added a few drops of sulphuric acid to a mixture of blue litmus, with a little water. D. The blue color was changed to red. E. Therefore sulphuric acid *is an acid.'* He should have written an inference of the kind which is indicated by his proposition, such as 'Therefore acids turn some vegetable blues to red." A child who cannot find his way across an open field in full daylight to the tree he started to reach is too young to succeed as a diver after hid treasures. Most scientific progress is made by getting in mind a definite question, pondering on some method for addressing this question to nature, making the experiment indicated, making the consequent observation, and deriving the inference which answers the proposed question. Perhaps Faraday could have made observations without knowing what he was looking for as well as any one. But when shown experiments by other scientific men, he was accustomed to insist on knowing first exactly what to look for, so that his whole attention should be rightly directed to the precise matter in question. So, we shall secure the best progress in our scholars if we lead them to formulate a definite question, and a method of getting the question answered, and then to reject as valueless every manipulation and observation and inference which they do not see to bear directly on this question and method. The man who thinks that a student can do much without knowing what to look for, if he really means what he seems to say, has not cultivated a sound judgment as to what is possible."

His grasp of the difficulties experienced in teaching science is shown by the following:

"Another difficulty in teaching science is that our methods of instruction in science are, by comparison with the methods in the long-established studies, pursued by students of the same age, somewhat crude and tentative. This is a real and serious difficulty. Latin and Greek and mathematics, on which the chief onus has fallen, have been well elaborated instruments for teaching during

centuries. Their methods are settled and established. There are, it is true, improvements from year to year, but there are no *radical* changes, no overturning. By comparison with these established, almost consecrated methods, our methods in science are crude and lack elaboration.

"In order to make plain my meaning, let us recall the three chief factors in education. We have, in the first place, to impart information. We have to teach subjects which are valuable principally for the information they yield. Geography is valuable as information. History is valuable, largely at least, for information. These subjects are valuable directly, and in themselves. In teaching subjects valuable for information, we have to guide the student in his selection, assist him in comprehension, and address ourselves to his memory. Another factor we might call mental furniture: the multiplication table is a bit of furniture. It has no interest in itself. Spelling is mental furniture to most of us; much of grammar is simply furniture. With respect to this part of an education the teacher's task is simple; he has but to assist the scholar to learn quickly and remember accurately. The third factor is power: The power to understand, the power to think, the power to reason; what a wonderful power it is. How much it costs! How greatly men differ in that power! In the power to express clearly a definite thought in an orderly sentence, how widely men differ. How much in the way of severe effort do they have to give for that power! How much men differ in the power of consecutive thought.

"Now, Latin and Greek and mathematics are so taught, their methods are so developed that they put before the student a succession of problems which he can, without loss of time, formulate and begin to solve. 'The laboratory methods of mathematics'—I once heard Sir William Thomson speak of a mathematical laboratory, and the phrase pleased me—the laboratory methods of mathematics and Latin and Greek are excellent, thoroughly well adapted to the student. One advantage is that no time is lost in setting before the student the nature of the problem which ought to be solved; another advantage is that nothing tempts the student to forget that it is by some mental effort that he is to

solve the problem. And the continual formulating of problems, the continual solving of problems by mental efforts develops power of a highly useful kind.

"But in the laboratory methods of science time is consumed in showing the nature of each new problem, time is consumed in getting the student to understand the method of solving the problem, and much time is consumed in the manipulation required. The time used in understanding the matter in hand is time in which the mind is *receptive,* rather than active; expectant, rather than executive. In the time consumed in manipulation, we all know how busy the fingers may be while the brain rests. After an hour or two of manipulation it is hard to convince the student that there remains any effort of serious thought needed. But, if you analyze the matter, you will see that out of the five processes which go to make up an experiment, four are purely mental processes. The laboratory methods of science are greatly handicapped by the fact that so much time is consumed, both by the teacher and the scholar, in putting him to work with his fingers. There is less time and strength left in which to compel him to think. We all have to fight continually against the danger of letting our laboratory methods in science dilute thought with manipulation. When you set a lesson in Vergil, you merely say, 'Take to the bottom of the thirtieth page. You have thereby set for a student a score or a hundred problems, each of which he can formulate with little loss of time. He knows also the method of solution with no loss of time. He can spend two or three hours in continuous and severe mental effort, hardly interrupted by the consultation of the dictionary. But, when he is given a problem in chemistry, or in physics, the case is different. We refrain from formulating his problem; we indicate its nature in some way, often by letting him read a description of it, and then he is to formulate it himself. It may take him ten minutes or more to think out that he is to write: 'A. To illustrate the law of definite proportions,' even when these words occur repeatedly on the page just read. Then it will take him perhaps longer to formulate the method of getting an answer as follows: 'B. By seeing whether 20, 30, 40 and 50 cubic centimetres of sodium hydroxide

require two, three, four and five times as much sulphuric acid for neutralization as is required by 10 cubic centimetres.' After these are formulated, there comes an hour or more of manipulation. After that the student has to think, 'How does my result apply to the question and method stated at the beginning, and how can I state this relation clearly, accurately and adequately?' This may demand ten or twenty minutes, or more.

"Now it is to be said that there are some advantages on the side of science. When a man has done these things, he has solved a problem much harder and much more profitable to him than any one of the score or the hundred problems which we have imagined as being assigned to him in the lesson in Vergil. But the point is, that after putting to our credit the ten or twenty minutes spent in the operation of reasoning and comparison and judgment in formulating the object and the method of his experiment at the beginning, and also the ten or twenty minutes given to reasoning and comparing and judging about the conclusion, there intervened an hour or more in which the mind was relatively inactive. That was an hour of effort not consciously directed toward a definite aim, but of effort directed chiefly by the physical phenomena around us. With a problem in Latin or Greek or mathematics, or with a series of problems demanding as much time as our single problem in chemistry, almost the whole time is spent in effort consciously directed to a definite aim, and it is such effort which cultivates power. Keeping the eyes and ears open furnishes information, but it does not develop power."

In view of the agitation of the question of the value of chemistry as a college admission subject, Professor Morley's ideas on this topic are timely. He says:

"Many students in our secondary schools study chemistry or physics or botany, not as preparatory to college, but as information courses. Of these I have nothing to say. But of those who study these subjects as preparatory to college, it is proper to speak in this conference of teachers from high schools and from colleges. For these latter students, the development of power is

the important desideratum. This we all know, though many who get the public ear in the public press seem not to agree with us. What are the results of that teaching of science in the school which prepares for college? How do the men who enter the scientific courses compare with the men who enter the classical course or the modern language course. It is not quite easy to answer this question. It is difficult to eliminate the differences in the quality of the men who select the different courses. When a modern language course was first opened to students, it was difficult to compare the results of this course with the results of the classical course, because we could not make the necessary allowance for the differences in the men who entered the two courses. At present, we can make this comparison with some degree of fairness. It is too early to attain the same degree of fairness in comparison of results of scientific and classical courses in the preparatory school. But it does seem to me that men who enter the Latin scientific course in this college have not had, in a year's study of chemistry, a full equivalent for a year's study in the older disciplines. It has been more largely a year of acquiring information, and less a year of self-directed mental effort. Those problems which were solved by the student of Latin or Greek or mathematics were not profound problems, and the mental effort was of an humble order. But it is that activity which is adapted to the age and condition of the student which develops power. In the year of study of chemistry we have not so well elicited that activity which is suited to the powers and the condition of the student. Walking involves but a humble physical process, but it is only by constant walking, day after day, that the soldier can march twenty miles in a day and be valuable as a soldier at the end of the march. It is only by a series of mental efforts, as humble, it may be, as the physical effort involved in walking, that the student gains a power fitting him for the work of the college.

"What are we to do? On that point but little can be said. One thing is that we must use all our ingenuity in putting our science before the student in such a way as will compel the processes of reasoning and comparison and judgment. Our suc-

cess in this depends on the teacher, and on his opportunities, on the equipment which he has at command, the time he has in the class room, the time he has in the laboratory, and the time he has for preparation.

"As far as laboratory study is introduced in the secondary schools, the emphasis ought to be put on something other than manipulation or observation. The ways which one teacher uses may seem whimsical to another. The students may be told, 'the hardest thing you have to learn is that you are here to *study*, not to receive manual training.' Perhaps they are told of what steps an experiment properly consists, and are requested to make their notes in accordance with this analysis. They may be directed to put under (A) the object of the experiment, under (B) the method of solving the problem stated in (A), under (C) the manipulation, under (D) the observations made, as far as they bear on (A) and on (B), carefully excluding anything irrelevant; under (E) the inference, being careful to exclude all inferences which do not bear on (A) and (B). Perhaps the teacher will wisely insist that no experiment be ever begun before object and method are considered and recorded in the note book, and may dismantle the apparatus set up or throw away the results attained, in case of a student who hastens to put sodium in water before he can take time to think whether he ought to propose to make hydrogen, or to show that water contains hydrogen. He may perhaps say that the student will be likely to suffer an uncomfortable five minutes, who confuses one of these five matters with another, and puts observation with manipulation, or inference with observation; and may be ingenious in ways of creating five minutes of discomfort for the thoughtless. He may insist that four-fifths of every experiment, as seen by this analysis, consists in a mental process, and laughingly encourage the student to spend at least a minute an hour in thinking. So, in a hundred ways, the teacher can assist students in remembering that it is mental development that they seek, and that it is the processes of reasoning, of comparison, of judgment, of invention, of discovery, which are to be exercised.

"In the recitation room something can also be done to make a

recitation somewhat more than a test of the memory. It ought to present to each student a problem in the art of putting a matter clearly and in well-ordered sentences. He may be led to see that to *understand* a matter is but a trifling attainment, as compared with a certain kind of *mastery* of the lesson, which enables him, when standing up to recite, to solve the problem of so putting that lesson before an intelligent audience as to be easily understood."

CAN WE INTEREST THE PARENTS?

BY E. L. MORRIS.

Under the conditions of teaching in the district schools of the eastern part of the United States, in the early days, the teacher, or school master, as he was called, was thrown much with the parents of his pupils. His contact with them was perforce to some extent, for he "boarded round" in the more well-to-do homes. He had opportunities of studying the home influences surrounding the boys and girls. He often could profit by silently listening to some home discipline, and from that time both in kindness to the parent and in justice to the boy, draw out the best in the overgrown youth. Boys and girls were misjudged by their parents, as now, because their parents failed to remember their own point of view at that age. Many were the teachers, however, of the prime of life, who knew well the awakening mind and life of the awkward student. In those days it rested on the individual character of the teacher whether he enlisted and turned to the profit of son or daughter the interest of the father as the family sat around the table after the supper things were put away, or won the sympathy of the mother.

In these days the situation is quite different, and more markedly so in the cities. In the country, the teacher can still retain some of the old-time influence through the parent's coöperation, especially if the students are few. In the towns and middle-sized school centers, there are more interruptions and fewer opportuni-

THE DISPLAY OF BIOLOGICAL WORK.
The Botanical Laboratory, looking southeast. (Taken by A. A. Doolittle, Instructor.)

ties and desires for social acquaintance between teachers and their constituents. In the larger cities, outside the corps of kindergarten and lowest grades teachers, there is among a few the feeling that naught but purely professional relations are desirable, while the opportunity for any other is very small. We certainly have today very little of the former knowledge by the parent of the teacher's work and the pupil's difficulties and successes. The value to the pupil and the teacher of all the coöperation which teachers and parents can give to each other has never been questioned. The fact that it has lessened, due to general trend of circumstances, is none the less patent.

The question which confronts us is how may the old-time benefits of coöperation be enjoyed under the present circumstances of so widely diversified interests. Under these circumstances, too, there must be grouped with the parents the public men and the childless taxpayers, the public press and opinion, of each community, then of each commonwealth of communities. To gain the coöperation and encouragement of these people is a much greater

labor than the school master had. Greater, because more of special effort is necessary to get their attention, to hold their interest, and to inspire their activity.

In an eastern city, under the need of bridging a gap which had formed by the development and change of the courses of study, the high-school authorities inaugurated the following plan. Various efforts had been made to acquaint and interest the public in the high-school work. For various reasons, unimportant here, the efforts were without appreciable results. But the people must be interested. So, in the spring, a demonstration was determined upon. It must be noticeable to attract the attention of the people. Invitations, printed, written, oral, official and personal, were issued by officials, teachers and pupils, to an "Open House" of the high schools. These "Open House" demonstrations were conducted one or two days in each of the buildings, so that citizens from every part of the city could find it convenient to attend. The hours were planned to further accommodate working people, as well as more leisurely folks. The invitations contained a statement of the features the public might expect to see. These features were representative work already done in the high schools and actual schedule work being done by the pupils in the regular classes. The instructors were engaged in directing the working pupils or showing and explaining the work to the people. The manual training exhibit was taken from building to building, instead of remaining at its own building alone. The other buildings showed practically their own work, there being a few exceptions in some departments. The language department had extensive sets of papers, both recitation and home preparations, as originally presented in every case, "corrected" or "uncorrected," and tables strewn with the text and reference books characteristic of each. The work in mathematics was largely the same, together with various blackboard demonstrations. Drawing and painting practically followed the plan in the sciences, given below.

In the natural sciences, perhaps, there was the most show, but none the less of training and education. The laboratories were in full working order. Regular work, by classes in course, done during the year or in progress, was carried on by the pupils. Each step in each kind of work was illustrated. The object, plan and

THE DISPLAY OF BIOLOGICAL WORK.
Zoölogical Laboratory, looking southwest. (Taken by A. A. Doolittle, Instructor).

results both expected and realized were posted. Everything was carefully labeled, giving all the information one might care to read. Instructors and student assistants were busy answering questions by the visitors. The buildings were crowded, every age and station being represented. The enthusiasm was great.

But the after effect was and is the better measure of the result. Greater personal interest by the parent in his child's work and success is very evident on every hand. The active pupils are showing a better spirit of work, probably because they then got their first bird's-eye view of high-school work. At the same time they thoroughly read every exhibited paper which they could understand. The public press has moderated in its criticisms on pending school questions, and has published fuller reports of school matters and interests, than had been the case. Larger appropriations are under way. On the whole, every line has been benefited by the aroused interest. Parents now come into the schools for better understandings and decisions, and for personal pleasure.

What can be done in places where circumstances differ from those met with in this experience?

BOTANICAL FIELD WORK IN SECONDARY SCHOOLS.

BY H. S. PEPOON, M. D.
Instructor in Biology, Lake View High School, Chicago.

I take it to be a proposition readily accepted by the up-to-date instructor in botany that plants are not simply to be studied as mere structural objects composed of cells and variously named parts, the end of such a line of work being a morphology of greater or less excellence; neither are they to be viewed as mechanisms with various parts performing each its own peculiar labor, the goal being a physiology of every known organ; but, rather, that linked to these in as firm a union as conditions will permit, there is to be added a knowledge of plants as living beings, affecting and affected by surroundings, animate or inanimate, and these factors in their ultimate outcome leading to changes in the plants themselves, or in the environment in which they are placed.

Speaking more particularly from the standpoint of the conditions as found in the Chicago high schools, I am certain that there never has been a time in their history more favorable for field study than the present. The botanical and zoölogical sciences have been accorded time more proportionate to their general and specific value as educational elements, and the whole school year is now given to each. This allows time to study phases and details of work which had to be omitted when the periods were shorter.

A whole year devoted to botany is a great advance, but there are many difficulties in the way of field work that can be appreciated only by one conversant with high-school methods and conditions. I propose to take up these difficulties somewhat in detail in the order of their real or seeming importance. To many these difficulties are not new, and my only excuse for presenting them is that I may offer some sort of solution or plan by which, in a large measure, the difficulties may be overcome.

In considering any such subject, there are, I believe, three dif-

ferent and perhaps somewhat antagonistic points of view to be remembered; that of the scholar, of the teacher and of the school in general, and it is only as we can correlate these that we arrive at less or greater success.

The great obstacle in the way of systematic field work in botany is the inflexible daily programme of the high school. A pupil takes four studies that come so many times a week on certain days and at certain hours. It is next to impossible for him to absent himself from Cæsar, geometry or English without seriously affecting his standing in those subjects. And yet it is often impracticable to have field study under the teacher's direction without some such infringement on the time of other studies. I am referring here, of course, to time taken from school hours. The matter is not presented in a much more favorable aspect if the systematic field work is attempted after school, for then the complaint is made that botany takes the time that ought to be devoted to study for coming recitations.

As a remedy for this condition the writer has tried double laboratory periods in the afternoon. With a programme arranged in this manner, classes may leave at noon for trips to the surrounding country, not occupying more than half a day, and no violence be done to other studies on the daily list. Such an arrangement is strongly advised, not that frequent use may be made of it, but that use *can be made*, when necessary. This, however, is of only limited application, and often not feasible at all with certain classes, and so may be considered a possible but only partial solution.

A second difficulty is the large size of the average high-school botany class. If the teacher be allowed to do field work at all, under his personal supervision, he cannot do it frequently with small classes, for this plan would beget the difficulty mentioned before. On the contrary, he must make infrequent trips with classes say of one hundred. Any teacher who undertakes to guide one hundred enthusiastic young botanists in field work, and sees that each one improves the opportunities presented as fully as possible will have a large and difficult problem to solve.

This difficulty may be partially met by making afternoon

trips with sections of the class. There is no remedy, however, if the entire class goes on the trip, and if the subject be properly presented, there will be no relief from limited numbers taking the subject as part of their school work, for both boys and girls will be earnest and eager workers in the botanical field, and there ought to be no method invented to discourage them.

Again, I have found by practical experience, that the expense to the individual pupil (if field study on a large scale is attempted), is often a serious matter. If the teacher wishes his pupils to learn the peculiar characteristics of, and the effect of environment on, the dune, bluff, ravine, valley, prairie, wood or marsh vegetation, trips to such localities are necessary, and will often be found beyond the means of many pupils. This is a subject demanding the serious attention of all educators, and the hope is expressed that the day is not far distant when steam and surface railways generally will make such rates for parties of pupils under the charge of instructors that the expense will be largely diminished and that this sort of country outing will be established on a permanent basis.

These are the chief obstacles to be encountered, but there are other minor ones that will cause more or less trouble. The regulations governing such field trips by our Chicago schools is a difficulty of possibly prohibitive effect, but it is to be hoped that time and a fuller appreciation of the value of such work may largely or entirely do away with such restrictions.

The disinclination on the part of the instructor is, I am aware, a delicate matter, for it would seem that the properly trained and enthusiastic botany teacher ought to delight in such labors, and, indeed, be it said to his credit, he generally does. We are prone to forget, however, that there are very many items of drudgery and clerical work inseparably connected with the teaching of science, botany being no exception, that use up vital energy and cause the tired teacher to long for rest, rather than for some fatiguing field trip.

Lastly, it will be found that a minority of the class do not take kindly to field work, as representing too much physical labor, perchance.

These several difficulties are largely gathered about the person of the instructor in a way that renders it very hard for him personally, to conduct this field work. Doubtless the best results are to be obtained only in this manner, but I am sure this is not the only manner in which good results are to be reached. I do not intend to minimize in any degree the influence the teacher ought to wield in all field work, but that such work is impossible without his presence is a grave fallacy. Original and helpful field work may be accomplished while the instructor remains within his laboratory, exerting, however, a controlling and directing influences over all the studies undertaken.

There are two distinct lines of field work that may be taken up by the botany class. The first has to do with the more or less exhaustive study of single types of plants, with all their surroundings of physical environment and competition and regulation by other organisms, plant or animal. It is desirable to obtain as thorough a comprehension of their life phenomena as possible, and all the elements that enter into their existence as *living beings,* capable of acting and reacting.

The second line of inquiry has to do with plants, in the aggregate; what are the reasons that influence the formation of similar structures in diverse plants when occupying like positions of growth; the determination of the rules and regulations that govern the great plant societies which give to the natural landscape such marked and characteristic features; the study of vacant lots and of circumscribed areas, working out in a small way the great problems of plant distribution.

In both these undertakings the fundamental idea is that the plant is not a mere inert *specimen,* merely to be pulled to pieces or cut up, but that it is a living organism, fully capable of working out for itself its own salvation, if surrounded by favorable environment, and capable also of materially affecting the careers of other organisms with which it comes into contact.

To carry out these two lines of work in a definite manner, so that definite results may be obtained, I know of no better plan than to furnish each student with outlines which will direct his studies in the field without the presence of the instructor. The

questions should be definite and should compel the pupil to *observe* and *to think.* Questions answered by "yes" or "no" ought to be few in number, but those in which reasons and conclusions are called for, in addition to correct observation, should abound. It does not detract in the least from the value of the resulting answers that some of them may be erroneous, or that wrong judgments are formed, or illogical or faulty conclusions drawn.

The following are outlines which have been used and found to be successful and are appended as suggestive aids:

A FIELD STUDY OF LICHENS.

1. General directions as to localities to be visited may properly head the outline.

2. Special *questions* and *observations.* Take notes and make sketches of important features.

(*a*) Upon what do you find lichens growing?
(*b*) How do they differ in different situations?
(*c*) If growing on trees, what parts of the trees are occupied? Why do they grow on such parts?
(*d*) Do they prefer live or dead trees?
(*e*) Do you think lichens injure trees? Give reasons.
(*f*) What colors do you observe?
(*g*) Is chlorophyll found in all specimens?
(*h*) Does the color remain constantly the same? Observe carefully and explain.
(*i*) What is the food of lichens?
(*j*) What protection have lichens from cold?
(*k*) Lichens may be found on buildings and fences. If so, what is the character of these structures?
(*l*) Examine carefully for animals.
(*m*) Lichens generally contain Pleurococcus. Why are they not as common as that plant?
(*n*) Why are lichens not common on street trees?
(*o*) What kinds of trees (if any special ones) do they prefer?
(*p*) What conditions favor the presence and growth of lichens?
(*q*) Examine carefully for fruiting "cups." Are they common or not?
(*r*) Why do so many lichens form "rosettes?"
(*s*) If possible, compare rock and tree lichens.
(*t*) Of what advantage to many lichens is their close contact with the objects they grow on?
(*u*) What effect has water on lichens? Why?
(*v*) Note any other interesting facts you may observe.

A STUDY OF A WEED COMMUNITY.

1. Carefully observe the different varieties found in a given area.
2. Take a census of each kind and make a table to show comparative numbers.
3. Examine each variety for peculiarities as to size and number of leaves; hairiness, general dryness, or succulence.
4. Examine the roots to determine character and the life duration.
5. If in season—examine fruits or seeds.
6. Answer, if possible, the following questions:

(*a*) If one kind is more abundant, find reasons, if possible.
(*b*) Why are most weeds annuals?
(*c*) How do perennial weeds differ from annuals?
(*d*) Why are weeds usually hairy?
(*e*) Why are most weeds of a dry nature?
(*f*) What character of flowers do weeds have?
(*g*) What becomes of all the seeds produced on a given area.
(*h*) Why do weeds produce so many seeds? Estimate the seeds in different varieties.
(*i*) What are the characters of weed seeds?
(*j*) What determines which weeds survive?
(*k*) Why is it so difficult to eradicate weeds?
(*l*) What effect has drouth on weeds? How do they compare in this respect with garden plants?
(*m*) Do animals usually eat weeds? What reasons can you find to explain the conditions in this respect.
(*n*) Do weeds serve any useful purpose? Explain.
(*q*) What are the qualifications of a successful weed?
(*p*) Why are weed areas not covered with the same weeds each year?
(*q*) How are weeds distributed?
(*r*) Why do not all weed areas have the same weeds?

A STUDY OF PLANT SOCIETIES.

1. Carefully observe all the plants of as many diverse areas as you are able to find, especially those that are very dry and very moist.
2. Examine for each plant the character of root, stem and leaf.
3. Tabulate results after seeking answers to the following questions:

(*a*) Compare the plants of each area as to stem growth (herbs, bushes, shrubs, trees).
(*b*) Examine for variety of forms in each area. Why are there often so many plants of one kind in a given area?
(*c*) Why do plants of dry places often develop tap-roots?
(*d*) Explain why plants with numerous fibrous roots, tap-roots or fleshy rhizomes may grow in the same dry surroundings.
(*e*) Where do you find plants with the greatest amount of hairy covering?
(*f*) Can you give any reason for result found in *e*?
(*g*) What protective devices do you find stems possessing?
(*h*) What relation do you find between soil and root form and extent?

(*i*) What relation do you find between moisture and root direction?
(*j*) What peculiarities of covering, if any, do roots have?
(*k*) Why do many plants have rhizomes or underground stems?
(*l*) Where do you find herbs with largest and smallest average leaves?
(*m*) Why do you find so few water plants that are not smooth?
(*n*) Examine carefully plants of dense shade for hairiness, leaf-size and other peculiarities.
(*o*) Do the same for plants always exposed to the sunshine.
(*p*) Examine given areas for plants related to each other.
(*q*) Study plants for a season. Do you discover spring, summer and autumn societies? What common features do you find for each?
(*r*) Can you find members of one society migrating into the area of another society? Do the migrated plants thrive?
(*s*) Sketch plant-society areas, giving soil, moisture and sunshine data, with census of *common* plants.

4. Seek for general rules governing plant societies, as shown by results of your observations.

The pupils with these outlines work on the subject when they choose, and as a rule are not accompanied by the teacher. When their reports are handed in, there is a general discussion by the class, that each may obtain the benefits to be derived from the observations of all.

At the same time the pupil derives four distinct and very important benefits from this kind of work: First, he learns how to do independent work without the presence of others; secondly, he learns correct methods of observation and how to record his observations; third, he becomes acquainted with plants as living beings; and, finally, he receives needed and healthful physical exercise accompanied by delightful mental stimulus.

THE OLD AND THE NEW IN PHYSICAL GEOGRAPHY.

BY L. H. WOOD.

Now and then we catch glimpses of the good work done in geography in some of our normal schools and universities; again and again we hear reports of the progress made in the German schools in every branch of geography; several good journals are constantly pushing to the front plans of work and exhortations to enterprise in this direction; excellent text books are being published, and some of the older and poorer ones have been laid on the shelf forever; teachers, generally, are alive to the conditions, and are satisfied that some great changes must soon take place in methods as well as material; these facts suggest "something new."

The use of the term "new" does not imply that no good work has been done in the past, nor that the old methods and the old teaching were all bad. Rather the "new" is an evolution, a survival of the best that thorough going teachers have used, coördinated with the recent ideas that are receiving the stamp of approval after a fair trial.

Like the phases of progress in other lines, the "new" in geography must come in gradually. Conservatism must temper enthusiasm. There is earnest devotion on the part of so many teachers to this subject, that the "new" may safely be grafted on the "old" and the two grow together until the graft becomes the fruit-bearing limb. Leading educators have already stated what the "new" should be, and in doing so have indirectly outlined the "old." So that, had *doing* followed sharply on the heels of *saying*, the new era would have been upon us long ago. But the inertia of the large mass of prejudice and ignorance must be overcome, and the "new," for some time, will be concerned with this task. The great universities and normal schools certainly have taken hold of this problem by the right handle. It now remains for superintendents and principals to do their part in coördinating the work of high schools and grades. This done, the millenium of geography will have dawned upon us.

As the high schools look to the universities for teachers to do a special work, so the grades must look to the high schools for teachers to do their special work of introducing correct methods in geography. As the high school supplies young teachers with correct notions of language, history and mathematics, so it should supply them instruction in the best methods of geography and normal ideas of what the material used should be. This creates a demand not only for teachers of the high-school branch of geography who know what the instruction in the grades should be, but also a certain part of the course planned with reference to the needs of the grades.

Such an arrangement of the high-school work need not impair the integrity of the secondary course in the science of physical geography, but will, as I shall try to show, be mutually beneficial to both classes of pupils.

The loose relation that exists between grades and between the grades and high school strikes me as the phase of the "old" most to be criticised at the present time. Where the superintendent is a disciple of geography, there is usually much stir along this line, and many plans and outlines are issued monthly, designed to systematize the teaching of the great mass of facts loosely combined under this subject. When the superintendent can teach the physical geography of the high school, he will, necessarily, flavor the programmes of work for the grades with the aroma of his own interest, and thus the high school and grades will be conrected in part. But this is not the case in most schools. In fact, what I have learned from the majority of schools that I have visited, and from inquiries made in many parts of Michigan, not even this loose relation exists. As Mr. W. H. Snyder, in an article written for this Journal (March and April, pp. 20 and 62), so pointedly says: "The geography of the high school occupies a place where there can't anything else be easily put; it is taught by the teacher who can't do anything else very well; taken by the pupil not exactly suited for anything; taught with any book that is easy." Such a condition exists largely because the study in the high school is really the culmination of nothing that precedes; is not closely related to the geography that has occupied

the mind of the pupil for several years of his grade work, and has not, so far, been sufficiently useful to grade teachers to make it worthy of its place. But give the study its rightful place as the coördinator of the many facts gathered from the study of many lands in the grades, the loom, as it were, in which the loosely connected facts of political, physical, commercial and biological geography are neatly woven together into the fabric "Geography"; make it helpful to the young teachers who go from the high school to the grades; introduce into the course some of its bearing upon history and civilization, and it will soon come to occupy no mean position among the culture studies so long holding the favored places on our high-school programmes.

How can this be done? How can the high-school course be brought into closer relation with the grade work? "Aye, here's the rub." What part of a system will make the teacher of physical geography, if not an integral part of the geography department, at least in sympathy with those teachers who bear the burden of the subject? Several things are necessary to take teachers and subject out of the "old" rut and balance things up on the "new" plane.

In the first place, some teacher well versed in the subject must be given charge of the department from cellar to garret. What would become of the department of music and drawing in our schools if there were no head? And what can be expected from geography where as many loosely-related topics are left to be patched into a connected whole by a dozen different people? The "new" in thought and method must be grasped by some devoted teacher, and its truths be preached from the housetops until the corps of grade workers is converted. *Then* coördination will have begun; one grade of work will not overlap another; high-school work will supplement grade work; physical geography will be introduced in proper proportion in the first grade as well as in the last, and the several phases of geography will come to receive, each its own share of attention in all the grades, because they have snugly nestled down to partnership in the mind of the teacher. In the past there has been too much dissection of the subject into its vital parts—into physical, political, commercial. A book has

been written in which the physical occupies the first half, and teachers have taught this text page by page, with the feeling that because the author was a great geographer, therefore the order of treatment should be religiously followed. This same book presents the physical geography systematically, in a more attractive form than do many of the high-school texts, with the result that when the pupil reaches the presumably more complete text he finds it dry and his interest takes a drop. Because this book emphasizes the physical too much, superintendents in many cases have gone back to the books that give the pupil more so-called information on the many important phases—as capes, bays, crooks and turns in the coast line, *et cetera,* from map questions. And as teachers turn once more to the cut and dried question-and-answer method of the text; so bad, because it binds the child down to too much serving of the text book, when his mind should be wrestling with the problems of his own environment and roaming to and fro upon the earth gathering data for the construction of his own geography. To overcome prejudice in this matter and institute a plan of work in which all the parts have their true balance, the specialist is needed. He must enter into the wôrk in geography in the grades, as the drawing teacher enters his department. He must teach and inspire the teachers whose views of the subject are generally narrow and who like, as we all do naturally, to do their own little piece of work, forgetful that their piece joins others to make up the whole.

Such a special teacher might teach the physical geography of the high school; for, knowing the condition of the grade work, he could properly coördinate the primary and secondary phases of the subject. He might call his high-school course simply geography, and in it offer the material in such a way as to supplement the necessarily fragmentary teaching of the grades. He could thus adapt his course to the needs of the school, and at the same time train teachers to enter intelligently upon the grade work. He would certainly be able to illustrate the principles of physiography by type studies, too, at various points of the earth, and make due reference to the multitude of facts that illustrate every principle that he brings before the class. Then he would prove truly that

physical geography is based on the earth and not on the text book. His course would not then be a conglomeration of a half dozen sciences, but would stand forth among them all in its true place as a science, holding its own with proper dignity.

It is to be supposed that the child leaving the eighth grade has been taught to apply the more obvious truths of physiography to history, and that many of the simple facts of nature are already his own private property, acquired by the use of his senses, in and about his own home land. In geography proper his work has dealt with facts rather than with relations; he has been working in the inventory stage of his science; he possesses a large stock of facts concerning form, size, position and location of the natural features of the globe. Home geography has been pretty fairly mapped out. He has also begun work in the second stage of his science by tracing the relationship of many distinct groups of phenomena. He has studied the relation between deserts and mountains, deserts and rainfall, rainfall and rivers, rainfall and fertility of soil, gulf-stream and climate, movements of the earth and climate, the effect of temperature on plants, water and animals, the effect of temperature on the air, and many other such sets of relations. He has, in short, looked out of the geographical window of his soul to view the panorama presented by the organic and inorganic phenomena of the round world. If the pupil has such an equipment as this he should be fitted for good, solid work in the real science, physical geography. Having seen considerable of the human element in geography and history he can consent now, for a time, to be led away to the purely physical phenomena about him.

As high-school teachers we must limit ourselves on the side of fact and open the window of the soul on the side of relations; for this is the distinction between the primary and secondary aspect of the science. We must cause the pupil to experience as much pleasure in his tide of emotions arising from his conquest of a world of relations as he formerly did from that of curiosity in the accumulation of the facts. We must teach him that the power of seizing relations is the passport to this new land of promise. Too often the child does not have this passport on coming

to the high school, but has, rather, a thorough dislike of the subject acquired through bad teaching. When this is true the high-school teacher must take the pupil as he is and not as he is supposed to be. He must re-dress the old facts and bring them out clothed and in their right relations. When we have reached the strictly "new" era the necessity for this elementary work in the high school will be done away, and the broad reaches of a world-wide, beautifully true science will be laid open to the student of our high schools and academies.

THE PURIFICATION OF MERCURY.

BY GEO. M. HULETT.

Instructor in Chemistry, University of Michigan.

Many methods have been proposed for the purification of mercury in the "wet way," that is, by using acids and oxidizing mixtures, such as nitric acid, a mixture of nitric and sulphuric acids, and especially a mixture of sulphuric acid and potassium dichromate.

The impure mercury is shaken up with these reagents, or it is allowed to fall in a fine stream through a long column of the reagent. But with these reagents, none of the metals which are below hydrogen in the voltaic series can be removed unless some mercury is in solution. When mercury is dissolved in the reagent, however, all metals down to mercury in the series can be removed, except gold, silver, potassium, etc. As these "noble" metals are seldom found in mercury, the wet way is useful. The best reagent is a solution of some mercury salt, and a nitric acid solution of mercury nitrate of medium strength answers all purposes. A large jar partially filled with this solution serves as a receptacle for all "dirty" mercury. The mercury to be purified is brought into a separatory funnel (Squibb's form with a glass stopcock and stopper is best), and covered with a freshly prepared solution of mercury nitrate and nitric acid. After the mer-

cury has been shaken vigorously with this solution for about five minutes, it is run into another separatory funnel, and the solution is poured into the dirty mercury jar. The mercury is now shaken with a little water two or three times to remove the acid, and finally dried by allowing it to pass through a pin hole in the apex of a folded filter paper. This leaves the mercury very bright and ready for all ordinary uses.

It is, however, often desirable to distil mercury, and this can be done easily with ordinary laboratory apparatus, using no better vacuum than can be obtained with an ordinary Sprengel aspirator or filter pump. A and R (Fig. 1,) represent two ordi-

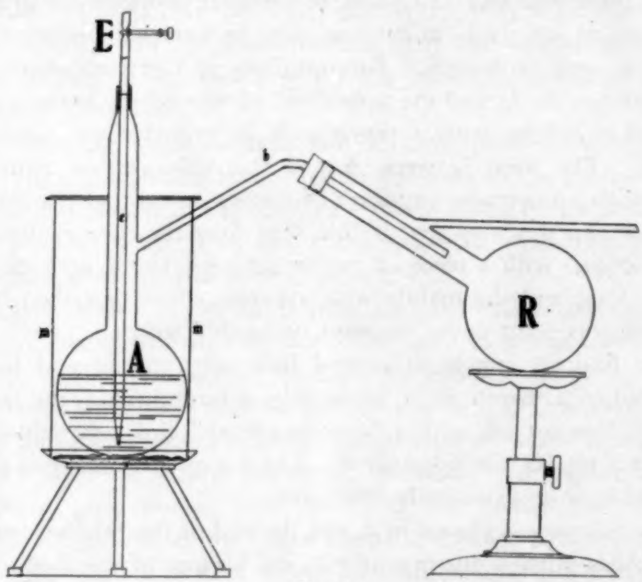

Fig. 1

nary distilling flasks of about half a liter capacity. The side tube of the flask A is bent first up and then down, and. if necessary, a short piece of tubing is fused on to this side tube to make it 30 to 40 cms. long, so that it extends well into the neck of the receiving flask R. The connection with R is made air-tight by means of a rubber stopper, or, better still, with a cork and sealing wax. The side tube from the neck of the receiving flask R is

joined to an ordinary Sprengel aspirator which gives a vacuum of from 20 to 30 mm. of mercury.

If one attempt to distil mercury under atmospheric pressure or in anything less than the best vacuum obtainable by a mercury pump, the mercury bumps and spurts beyond all control. But if gas bubbles are allowed to pass slowly through the mercury, it boils gently under any pressure, and in an ordinary Sprengel aspirator vacuum at about 210°C. This use of gas bubbles to prevent bumping in liquids being distilled under reduced pressure is quite common in Organic Chemistry manipulations.

To introduce the air bubbles, a piece of common tubing of rather thick wall and 6 to 8 mm. in diameter is drawn out to a fine capillary at one end—about one mm. in external diameter and 10 to 20 mm. in length. This capillary end extends down into the mercury in A, and the upper end of this tube *c* bears a piece of rubber tubing with a pinch cock to regulate the admission of air. The joint between A and this tube can be made air tight with a minimum exposure of rubber or cork, if the neck of A be drawn down so that it just slips over the tube *c*, the joint being closed with a piece of rubber tubing. If the neck of A is rather long and the mantle with asbestos cover described below is used, this joint never becomes noticeably warm.

The flask A stands in a sand bath on a tripod and is surrounded by a mantle *m m*, made from a large beaker, the bottom of which is cut off with a "cracking coal," and a slit cut down from the top for the side tube *b*. The top of this mantle is closed by means of an asbestos board cover.

The mercury is placed in A and the end of the capillary part of the tube *e* pushed down nearly to the bottom of the flask. The aspirator will soon reduce the pressure to about 25 mm. of mercury, if the joints are tight. Then by slowly opening the pinch cock, a slow stream of bubbles is allowed to break up through the mercury. A Bunsen burner serves as a source of heat, as a temperature of only a little over 200°C. is needed under the diminished pressure. The distillation can proceed quite rapidly without any danger of spurting, and when once in operation, the apparatus requires no attention whatever. One can safely allow

all the mercury to distil over, as the flask will not break and the last portion is quite as good as any. My results showed the absence of foreign metals in any part of the distillate (and it was possible by the method used to detect, for example, one part of zinc in 100,000,000 parts of mercury).

If any metallic oxides are present, they are liable to be mechanically carried over, and form a coat or covering on the mercury, but no *metal* except the mercury goes over. The oxides, if present, are easily removed by filtering through a pin-hole in the apex of a folded filter paper.

This apparatus is readily constructed from material found in most laboratories. It has a far greater capacity than the Weinhold mercury still; it distils more rapidly and possesses the decided advantage of distilling all the mercury, whether a few grams or kilograms.

In distilling from an iron still at atmospheric pressure, the bumping and spurting leaves one in doubt as to the purity of the distillate. This difficulty could be easily obviated by forcing a slow stream of air from any compressor, or hydrogen from a generator through the boiling mercury.

Pumice stone, pieces of porous plaster, hollow tetrahedrons made of platinum foil, etc., are often used to prevent bumping. They owe their efficacy to the little air bubbles which are liberated from them and tend to restore the equilibrium between a liquid and its vapor. The liquid in the interior where it is not in contact with the vapor becomes superheated; a bubble of an indifferent gas, brought into the liquid, acts as a vacuum to the vapor, and as soon as the vapor forms in contact with the superheated liquid, the system is out of equilibrium, and there is a rapid evolution of vapor while equilibrium is restored. The return to the equilibrium temperature is often so rapid as to cause explosive effects. The gas bubbles prevent superheating, and the liquid boils quietly at the equilibrium or boiling temperature.

Porous substances, after a time, lose the gas on their surfaces or in their interstices, and so become ineffective. A slow stream of bubbles of an indifferent gas is generally more effective. If working under diminished pressure, one uses the pressure of the

atmosphere to force the gas through the boiling liquid, and at atmospheric pressure, one can employ a gas from a gasometer, gas cylinder or generator, according to the nature of the gas to be used.

A DEMONSTRATION OF THE WEIGHT OF A LITER OF CARBON DIOXIDE.

By C. E. Linebarger.

There are comparatively few quantitative experiments which are adapted for performance on the lecture table, as they require more care and attention to insure good results than can usually be given during the lecture. And yet the desirability of giving some quantitative work in the lecture room can hardly be questioned. A fundamental demonstration is the determination of the weight of a liter of a gas, and in schools where the laboratory work is purely qualitative, such a demonstration becomes almost peremptory. Carbon dioxide is a gas well suited for such purposes. The methods which have been in vogue are, however, rather unsuitable for demonstration, although they may be made to yield satisfactory results in the laboratory as an individual experiment. The method described in this paper permits of the weighing of a liter of carbon dioxide with a satisfactory degree of accuracy, and in a reasonably short time, and further does not demand any protracted or delicate manipulation. If the class is familiar with the reduction of gas volumes to standard conditions, the demonstration from start to finish ought not to take more than half an hour, and the actual manipulation of the apparatus, apart from the weighings and measurement of the volume of the gas, does not require five minutes.

Recently there have been placed upon the market steel capsules* filled under considerable pressure with carbon dioxide.

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* Their trade name is "Sparklets."

They are manufactured for the purpose of making sparkling or soda water in small quantities, a bottle of special design being provided with a simple device to open the capsule and discharge the carbonic acid gas into the water with which the bottle is filled. The "pint size" of these capsules contains about two grams of carbon dioxide, and the capsules weigh about six grams each. With these capsules, the exact weight of about a liter of carbon dioxide may be found; the capsule is weighed, then opened so that the compressed gas may escape, and the capsule, now filled with air, reweighed.

The apparatus employed is shown in Fig. 1. With the excep-

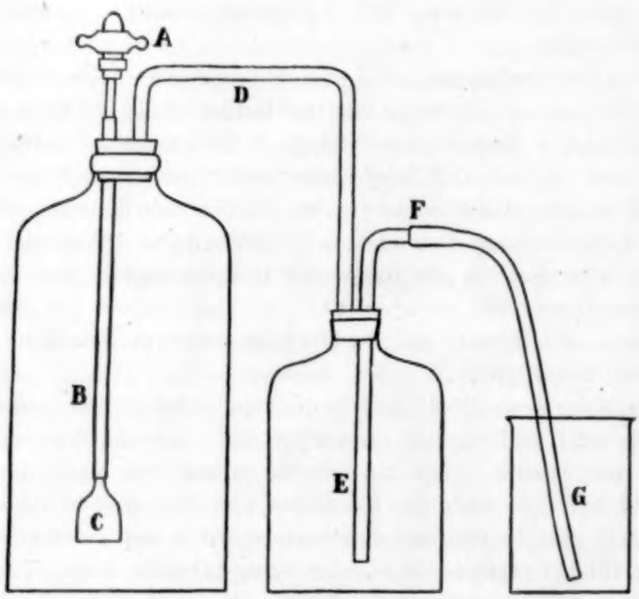


Fig. 1

tion of the "capsule opener," the parts of the apparatus are to be found in every laboratory.

B is a large bottle, the larger the better. An "acid bottle" will do, if the vertical branches of the tube D are as long as possible so as to make the space through which the carbon

dioxide has to diffuse before reaching the water quite considerable. This bottle is fitted with a two-hole stopper, best of rubber; through one hole passes the tube of the "capsule opener" A, and through the other a glass tube of wide bore, bent at right angle. A piece of rubber tubing is slipped over the lower end of the tube of the "capsule opener," to which is joined a little funnel C, made by drawing out a test tube. The object of the funnel is to allow the carbon dioxide to spread out a little on entering the bottle, and thus to decrease its speed somewhat. A smaller bottle, E (a two-liter size is good), is fitted with a two-hole stopper through which passes a wide tube making connections with B, and an L-tube over which is slipped a piece of rubber tubing about 30 cms. long. G is a beaker or bottle of about two liters capacity.

Before the demonstration is shown to the class, the apparatus should be set up all ready on the lecture table, E filled with water, which is drawn over through F, so as to fill it also with water, and the end of F kept under water in G, which is raised up and supported by blocks so that the water will nearly fill E, and yet the levels in G and E will be the same. Especial care must be exercised in pushing in the stoppers tightly and having all connections tight, as when the gas escapes from the capsule, it does so with a rush, and the pressure suddenly developed may force out the stoppers.

A capsule is weighed (to a centigram is sufficient), placed in the "opener," and the cap screwed down almost hard enough to pierce the capsule. The tip of the rubber tube in G is then pinched together with the forefinger and thumb, and lifted up so that G may be emptied and drained for a few seconds. The rubber tube is replaced in G, care being taken to keep its tip always below the surface of the water. Without delay, the cap is screwed down (the "opener" being held with the little wrench) so that the pin punctures the capsule. As the gas escapes, it displaces the air in B, which in turn displaces the water in E. In this way the carbon dioxide does not come in contact with the water at all, or, at least, not for some time. As soon as no more water appears to flow into G, which is the case in a few

seconds, it is lifted up so that the level of the water in it and in E are the same, and the apparatus is allowed to stand for a minute or so in order to bring the pressure in the apparatus to that of the atmosphere. In the meantime the thermometer (which had better be kept inside the large bottle all during the experiment) and barometer are read. No correction for aqueous tension has to be made, as the carbon dioxide is dry. The tip of the tube in G is again closed with the thumb and the finger, and lifted out. The volume of the water in G is found by pouring it out into a graduated cylinder or flask. All that remains to do now is to find the weight of the capsule emptied of carbon dioxide.

It is my practice to have the class work out the calculations for the reduction to standard conditions, which keeps them occupied, while I weigh the capsule. We then together calculate the weight of a liter of carbon dioxide from the data obtained. The values we have thus far found are 1.96, 1.98, 1.99, 1.96, and 1.98, which agree well with the accepted value, 1.97.

Care must, of course, be taken to remove all the carbon dioxide from the large bottle, before making a second determination. This is readily accomplished by pouring the gas out, as if it were water.

Although this experiment has not been put into the hands of students to perform individually, there do not seem to be any good grounds for believing that it would not prove to be a good students' experiment. The apparatus does, indeed, take up considerable room, but several of them set up on a side table would suffice for a large class. One thing that certainly recommends the experiment for students' use is the great certainty that good results can be obtained even with comparatively careless handling.

A GALVANOMETER FOR THE LECTURE TABLE.

BY C. F. ADAMS.
Instructor in Physics, Detroit Central High School.

It has occurred to me that an arrangement of a lamp and galvanometer for the lecture table, which I have used for some time and which has proved very satisfactory and convenient, might be of interest to the readers of SCHOOL SCIENCE. The galvanometer is a d'Arsonval of the earlier type, having a coil made of No. 36 wire, with a resistance of about 100 ohms. It has a plain, box-like case of walnut, with a plane glass front, 2½x9 inches, and was made in the shop connected with our laboratory. The mirror of the galvanometer is concave, about seven-eighths of an inch in diameter, and has a radius of curvature of about 20 inches. This galvanometer is sufficiently sensitive for the most delicate earth induction experiments.

In my first arrangement I used a plane mirror. A hole 2 inches in diameter was cut through the top of the table and an electric lamp fixed in position under the hole. A convex lens was placed over the hole and the light from the lamp was reflected upon the galvanometer mirror by a plane mirror placed above it. The galvanometer was so placed that the image of the lamp was projected upon a curtain or wall. While this arrangement was very good, it was not so convenient or effective as the arrangement with concave mirror described below.

In this arrangement (Fig. 1) the lamp is contained in a box about 16 inches long and 8 inches square. The plane mirror M is attached to a rod (not shown in the figure) set in the box so that it can be adjusted in height and in angle. In this way small adjustments for focusing can be made, as the distance the light has to traverse from lamp to concave mirror is changed by raising or lowering M. The side of the box is on hinges, so that it can be dropped down and the arrangement shown to the class. Two of the leveling-screws supporting the box rest

on brass plugs set in the top of the table, and thus connect the lamp in the box with the lighting circuit of the building.

The galvanometer is fastened by screws permanently in its position on the top of the box and a switch is placed on one side of the box for the purpose of short-circuiting the galvanometer and damping its vibrations, or it may be used as a shunt to render the galvanometer less sensitive. The curtain is 10 or 12 feet from

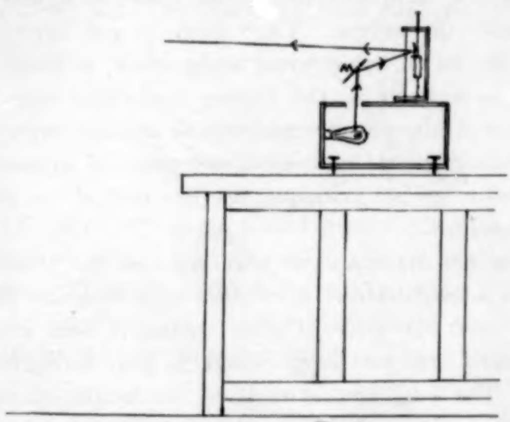


Fig. 1

the galvanometer and the image of the lamp is so bright that the room need be only partially darkened, not so much but that all that is done on the lecture table can be seen readily.

Not the least valuable feature of this arrangement is the fact that it is always ready for use. No time need be used in making adjustments. The whole apparatus needs only to be picked up, set in its place on the table and the coil lifted when it is ready for use. When not in use the coil may be held in position by two small brass rods extending through the galvanometer case, and except from the fact that the mirror is liable to fall off, the whole apparatus may be carried about by a handle on one end of the box almost as safely and conveniently as a valise.

HOME MADE APPARATUS.

BY A. C. NORRIS.
Instructor in Physics, Little Falls (Minn.) High School.

No feature of SCHOOL SCIENCE has interested my pupils more than the articles which have described some piece of apparatus which they can make themselves. They seem to get twice the profit and enjoyment out of some home made affair, although it is not as fancy or as accurate as the factory made appliance. I would like to make a strong plea for teachers to send in any ideas they have along this line. If you have any piece of apparatus which illustrates some law or principle, let the rest of us know about it. Don't be selfish.

Our physics class has made several novel appliances. One boy proposed a plan for a lung tester. It consists of a test tube fitted with a perforated cork. A piece of glass tubing is bent into a U-tube, with the short arm just long enough to pass through the hole in the cork. The long arm extends to the height of eight or nine inches. The tube is filled two-thirds full of water and the cork inserted, and when the tube is inverted the water will rise in the long arm. By slipping a short piece of rubber tubing on the long arm we have an accurate lung tester. By measuring the diameters of the tube and tubing, the number of pounds pressure can be easily computed.

Our lifting machine consists of a lever sixty-six inches long, fastened into a block six inches from one end. At the end of the long arm is fastened a fifty-pound spring balance. At the end of the short arm is a rope, which passes through a pulley fastened to the floor. In this way, the pull is always upward. We use this apparatus in a number of experiments in physiology when studying the muscular system.

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY.

BY GEORGE W. MYERS.

(*Continued from page 374.*)

Experiment XIV.

Trace and learn the positions of the Celestial Equator and the Equinoctial Colure among the stars.

(A chart such as those of Upton's *Atlas,* or a planisphere, such as that of Poole Brothers, Chicago, or Mary Proctor (William Beverly Harrison, 42 East Twentieth Street, New York,) will be helpful for this. The latter planisphere can be had of the publishers at the cost of about $1.00. The atlas costs about $1.50.)

Experiment XV.

To find the rate of the moon's monthly motion.

(a.) Chart the position of the moon, some evening, with reference to any three bright stars near enough it to permit an estimate (with the aid of the hand as suggested in Experiment II) of their distances from it to be made with some accuracy, and the selected stars should be bright enough to be identifiable on consecutive evenings. Write the estimated distances from the moon to the various stars on the chart. Use a note book having a page large enough to admit of entering two or three evenings' observations on it. Each observation should be dated to the nearest minute. Estimate as nearly as possible from your charts how far the moon has moved among the stars from the first to any subsequent observation, and from this compute the time of a complete revolution of the moon through 360°.

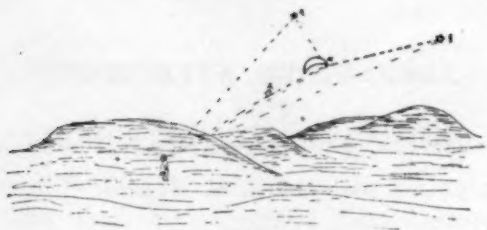


Fig. 16.

(b.) These same distances may be measured with a cross-staff, (See Fig. 15), a sextant, or with sticks.

Query: Will this give the length of a sideral or of a synodic month?

Experiment XVI.

Identify the group of stars known as the Great Dipper, or the Great Bear; the Polestar, the Lesser Bear, and Queen Cassiopeia's Chair.

(The five brightest stars of the latter make a figure resembling a poor capital W.)

(a.) Upton's *Atlas,* or Mary Proctor's planisphere will be helpful to any who may need help in this experiment. Note that the line of the two bright stars in the outer edge of the bowl, when prolonged upward about five times the distance which separates them, passes near an isolated bright star. This star is the Polestar, called Polaris, and the two Dipper stars are, from this accident of position, called the "Pointers." The Pointers are 5.4° apart and this may be used as a standard for estimating the angular distances between heavenly bodies. Other distances which are sometimes useful, are:

α to γ Ursae Majoris - - - -	10°.0
α to ϵ " " - - -	15°.2
β to ζ " " - - -	20°.0

Having identified a number of objects on the sky and learned something of their motions relative to each other, we may now pass to a study of the motion of the sun relative to the earth.

EXPERIMENT XVII.*

To measure the altitude and azimuth of the sun.

Definitions—By the altitude of the sun is meant the angular distance of the sun above (or below) the horizon, and by the azimuth, the angle between a vertical plane through the sun and the plane of the meridian.

Construction.

Cut from inch stuff and surface two boards of dimensions shown in the cut. Square up one edge, *PN,* of the square board to an accurate right angle with the adjacent face *MNPO.*

Use.

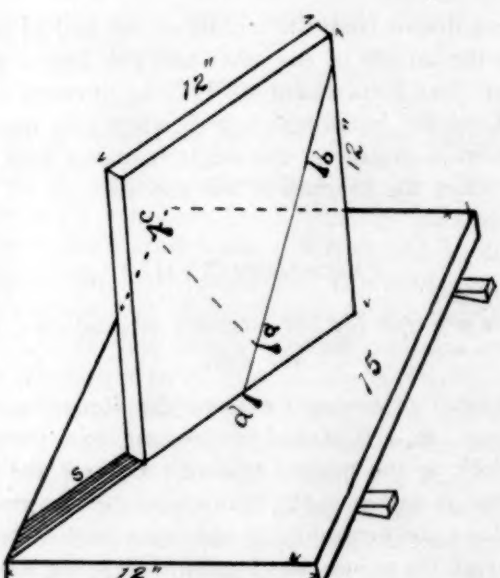


Fig. 17.

*See foot note, next page.

By the aid of the wedges place the rectangular board horizontal (indicated by pouring a little water upon it), and then set the square board edgewise upon it and edgewise to the sun in such position as to make the shadow at *s* as narrow as possible. Stick a pin in the face of the vertical board at *a* about 2 inches from the edge *PN*. Now, stick a second pin at *b* so that its shadow shall fall upon that of pin *a*. Turn the board about so that edge *OP* shall be toward the sun, and make the shadow *s* its narrowest again. Stick a third pin at *c*, as the pin *b* was placed formerly. Through the pin-marks draw the lines *ab* and *ac*, and with a protractor measure the angle *bac*. One-half of this angle will be the angular distance from the sun to the zenith for the mean of the times of sticking the pins at *b* and *c* respectively. Why?

Subtract this half angle from 90° and the difference will be the altitude of the sun above the horizon for the same time. Why?

One-half of the exterior angle *cad* will also be the altitude. Why?

If a line is drawn from the middle of one end of the horizontal board to the middle of the other and this line is placed on a meridian line (See Experiment XVIII) by drawing a line along the edge, *d*, on the horizontal board, when *s* is narrowest and measuring with a protractor the angle it makes with the meridian line, we have the azimuth of the sun also.

Experiment XVIII.*

To construct a graph for the altitudes or azimuths, throughout the day.

Let a number of students execute the foregoing experiment for eight, nine, ten, eleven, and twelve, one, two, three, and four o'clock. Work to the nearest minute. Lay off the times on a horizontal line as shown in the figure, and the measured altitudes on vertical lines corresponding to the times, and draw a continuous line through the points thus located. Drawing any horizontal line, as A B, and bisecting it with a perpendicular, the intersec-

*See Comstock's Text-book of Astronomy.

tion of the perpendicular with the curve will indicate the time by the clock used at which the sun's altitude was greatest. This is known as *apparent noon.*

By measuring the vertical distance from the horizontal line C D up to the curve we have the altitude for any time during the day. By measuring the distance to the foot of the perpendicular, we obtain the time of apparent noon, as shown by the time-piece used.

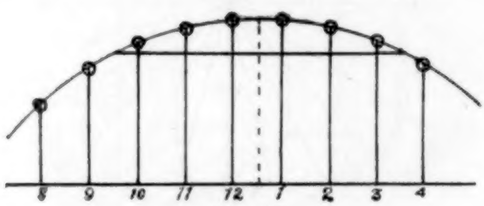


Fig. 18.

The entire curve brings before the eye the law of the sun's variation of altitude for the day.

Such curves, made at different seasons and compared, are instructive in many ways, which will readily occur to the teacher.

Experiment XIX.

To determine the form of the earth's orbit.

(a) Using the values of the solar diameter and of the differences of the sun's longitude for fifteen-day intervals, from the *American Ephemeris* (this book, which should be in the library of every high school where astronomy is taught, can be obtained from the Superintendent of the Nautical Almanac Office, Washington, D. C., by sending $1.00), plot the positions of the sun on lines drawn through a point (O) at angles (AOB, BOC, etc.) equal to the 15-day differences of longitude and at distances (OA, OB, OC, etc.) inversely proportional to the angular diameters. The first line (OA) may be taken any convenient length.

(b.) It may be instructive to make use of the apparatus of Fig. 13, using colored spectacles to protect the eyes in making the settings of the edges of the cards on the limbs, (edges) of the sun's disk. Can the measurements of the diameter of the solar disk be made with enough accuracy to bring out the law of change

of the distance from the sun to the earth from week to week, or month to month?

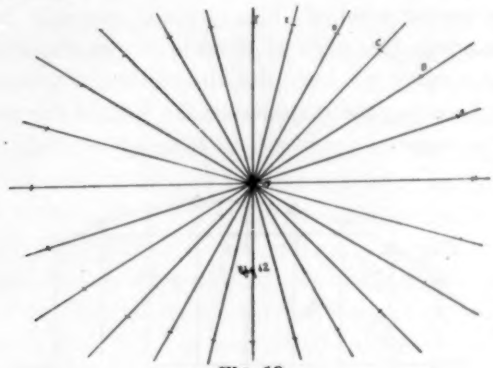


Fig. 10.

(c) The same kind of measures may be made for the moon, (See Experiment IX), using two-day intervals. Is the instrument capable of sufficient accuracy to bring out the law of the moon's changing distance from the earth?

(d.) The *American Ephemeris* data for the moon may be used in the way suggested under (a) for the sun. Try it.

Experiment XX.

To establish a meridian.

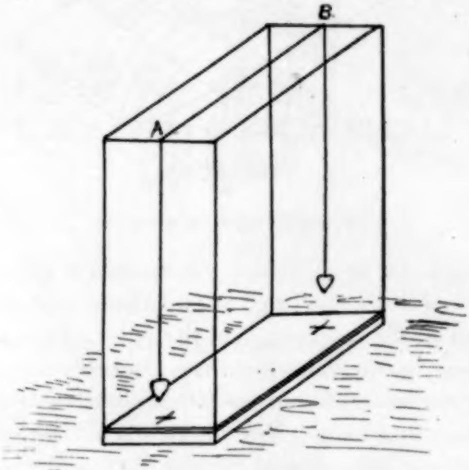
(a) Without a time-piece.

(1) By the Polestar and plumb-line.

Set four vertical poles, or pieces of gas-pipe, 6 or 7 feet tall, in the ground at the four corners of a rectangle 5 x 10 feet, the long dimension being placed approximately (by guess) north and south. Connect the tops of the poles with horizontal cross-pieces to hold them in place. Attach a heavy weight (a brick) to each end of a smooth cord, 22 to 24 feet long, and hang it over the middle of the middle points of the north and south end cross-pieces. Allow the ends of the cord to hang freely, the weights held at about the same distances from the ground, and low enough to allow them to swing freely in buckets of water if the wind is strong.

By glancing at a star atlas, it will be seen that Delta Cassio-

peia,, Zeta Ursa Majoris (the star at the bend of the handle of the Great Dipper), and Polaris, (the Polestar), are all on the same



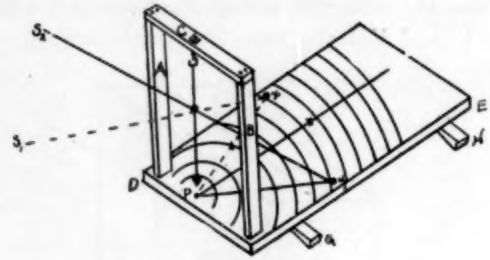
Plumb-line Transit.
Fig. 20.

celestial meridian, or hour circle. They are therefore in the meridian of any place at the same instant. If, then, an observer station himself behind (south of) the south plumb-line, and look northward at about the time either of the two first mentioned stars comes to the meridian, he may shift the plumb-line nearest him toward the right or left until this star and Polaris are just covered by the plumb-lines, at which instant the plumb-lines will be in the meridian. If the cross-pieces are now notched a little just where the cord lies, the plumb-line will always indicate the meridian by placing it in these notches.

If plumb-bobs are used, the points just beneath them may be transferred to the ground, or to a stone placed in proper position, and the meridian may then be identified at will.

(2) By observing the sun.

Suspend a plumb-line near the middle of a board on which a number of concentric circular bands, alternating black and white (black lines between white spaces will do), struck with the point *P* of the board just beneath the plumb-bob as center, and provide the plumb-line with a sliding bead. (See Experiment XXV.)



Plumb-line Gnomon.
Fig. 21.

Note the point (x) of any circle where the shadow of the bead crosses it in the morning, and the point (y) where the same circle is crossed by the shadow in the afternoon. Connect these two points with the center of the circle and bisect the angle between the connecting lines. The bisector is in the meridian (if the board DE has not been moved meanwhile), and the line may be readily transferred to and fixed upon the ground.

(b) With a time-piece.

Obtain the correction of the time-piece by methods to be given later, and compute the time when the star should be on the meridian. If the time-piece is rated to keep sidereal time, the right ascension of the star, obtained from the *American Ephemeris,* will be the correct time when the star crosses the meridian above the pole (upper culmination), and this right ascension increased by 12 hours will be the correct time of lower culmination.

If the time-piece keeps mean solar time, the sidereal time can be found approximately by adding to mean solar time 2 hours for each month, and 4 minutes for each odd day, since the Vernal Equinox (March 21st). The table at the end of the *American Ephemeris* will make possible a more accurate determination of the sidereal from the mean solar time, and vice versa. After the sidereal time has been determined, it may be compared with the right ascension as before. The difference is the *correction* of the time-piece, + if it is slow, or — if fast.

(To be continued.)

Metrology*

PARTIAL USE OF THE METRIC SYSTEM THIRTY-FIVE YEARS AFTER LEGALIZATION.

[CONTRIBUTED.]

(*Concluded from page 382.*)

The following sentences are quoted from the *American Manufacturer:*

"The metric system is making some headway among American manufacturers engaged in the export trade. This is especially true of machinery builders. It will continue to make headway according to the increase of our exports."

* * * * * * * * * *

"There are firms that have adopted the metric system for their export business. They do not seem to be suffering from the effects of having two sizes of templates and dies for their plants. They are filling orders for export and are teaching their workmen the use of the metric system in so doing."

The incongruity of having two sizes, whether there seems to be suffering from the effects or not, continues until the superseding in domestic trade also of old weights and measures by metric. A similar remark may be made in regard to United States importations of bottled goods, textiles and other manufactures from foreign countries where the metric system is in use.

Consider bodily measurements, etc. The stature and strength of athletic young men in the colleges in different parts of the country are recorded in metric units and are published; but sometimes the newspapers, instead of recognizing the kilos, call them "points." Dimensions of statuary, etc., have been given metrically in the reports of the Boston Museum of Fine Arts regularly for many years. There is great convenience in measuring the clothes, as well as the body, in centimeters, not requir-

*Communications for the Department of Metrology should be sent to Rufus P. Williams, Cambridge, Mass.

ing fractions; and among men's furnishing goods some suspenders may be found with the length marked upon them in centimeters; but there remains in principal use for the measurements of tailors and dressmakers, and for sizes of such things as gloves and hats, the old unit with the ubiquitous fraction.

Consider applications of science. The metric system has been thoroughly adopted for scientific research upon all subjects and for the diffusion of scientific knowledge by publications and educational institutions. The extent of its use for instruction, laboratory supplies, apparatus, etc., is enormous; yet when scientific knowledge is utilized in technical work or for commercial purposes it often happens that old units of measurement are employed; so we have the incongruity of preaching one thing and practicing another, of producing certain effects with one measure in investigation and with another measure in business. Such complications are now a characteristic feature in our literature, the discussions of our professional organizations, reports of committees of research, periodical publications, or books of the day. Similar complications are common in shops, offices and practical work, a fact so familiar as to require little illustration. Fineness of sand is expressed by the millimeter, and fineness of the sieves and screens for it by the number of meshes per inch. It is by the cubic centimeter of water that the number of bacteria are reckoned in biological examinations, but, rather than say so, men otherwise intelligent have sometimes disguised it for the popular mind as "thimbleful." Opticians have adopted metric measure, and, besides whatever else they have done in regard to their apparatus and accessories for microscopy, etc., they have a metric basis for expressing the power of lenses of spectacles. Their "dioptrics," depending on the focal length in meters, are found in the optician's price-list; yet it is not uncommon to express the diameters of lenses in old measure, which may be found even in the same catalogues that give generally the metric system.

It is needless to marshal further evidence. The cutting off of the dog's tail is by centimeters, so that the tail may continue in some measure to wag the dog, as long as he likes to have the operation protracted.

NOTES:

Progress of the Metric System.—The following are some indications of recent progress in metric reform:

1. The British consul at St. Petersburg writes that "the Russian government has in principle adopted the metric system, but no definite decision has yet been arrived at in respect to its compulsory use in Russia."

2. The Committee of the Associated Chambers of Commerce of Great Britain has adopted the following among other resolutions: "That after considering various suggestions this Committee is unanimously of opinion that the Chambers should unite in urging upon the Government the compulsory adoption of the metrical system of weights and measures, leaving matters of detail to be considered later."

3. Secretary Johnson, of the Decimal Association, writes from England: "Our colonies are displaying much more interest in the question, which is well to the front in Australia, Canada and even in Cape Colony in spite of the war."

4. United States Consul Hill reports from Amsterdam, Sept. 7, 1901: "The necessity for United States manufacturers to adopt the metric system in foreign trade becomes daily more imperative."

5. Representative J. F. Shafroth has introduced into the national House a bill for the compulsory use of the metric system by the various Departments of Government—similar to his bill in the last Congress.

6. The American Metrological Society has just appointed a Committee on Legislation, consisting of Professors Simon Newcomb, S. W. Stratton, J. H. Gore, Dr. W. H. Seaman, Supt. O. H. Tittman and ex-Minister John A. Kasson, to confer with the House Committee on Coinage, Weights and Measures, with reference to the passage of a metric bill. This Committee, from its recent conference with the Postmaster-General, reports that there is "every reason to believe that he will look with favor upon the use of the metric weights in his Department."

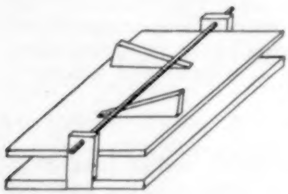
R. P. W.

Notes.

BIOLOGICAL.

Primula abconica is very suitable for starch-making in the leaf to use in place of *Nasturtium* in the experiment given in most text books. It can be had in greenhouses and is even more efficient than the latter plant.

Central High School, Detroit. BERNICE HAUG



A Simple Plant Press.—To the ends of a 1¼-inch board of suitable length and breadth two upright pieces of board are nailed. Near the tops of these bore holes directly opposite each other and put a cylindrical stick (broom stick) through them, or nail a piece of narrow board, beveled on the under side to fit a pair of opposite wedges, to their tops. Cut a pair of strong wedges from an inch and quarter board, about one inch less in width than the space between the stick and the base-board. A board small enough to go between the upright pieces and cover the base, completes the press. Arrange the specimens on the large board and drive the wedges beneath the stick. As the specimens dry the wedges are driven in deeper.

Central High School, Detroit. BERNICE HAUG.

Simple Method for the Examination of Blood.—It is not difficult to get a bit of human blood by twisting a handkerchief tightly around the thumb, bending it strongly and pricking with a sterilized needle in one of the creases. But to keep the corpuscles from shrinking has been by any ordinary means, except the warming stage, an unrealized desideratum. After trying various ways I have found that mounting in saliva will keep the majority of the corpuscles in good form and generally show the rouleau pattern of the red ones, while the white ones retain a spherical form.

To avoid getting more air than the saliva contains it is best to put the saliva on the surface to be pricked so that it will mix with the escaping blood.

Sealed by vaseline or paraffine around the cover-glass, such a mount may be used for several hours.

L. M.

The Cleaning of Slides, especially of a large number, is an irksome task. The drudgery of this kind of work may be considerably lessened by the use of the following simple devices, and the rapidity with which slides can be cleaned is much increased by their use. A base board about 12 cm. in breadth and of any convenient length and thickness has a cleat about 2 mm. thick and a centimeter or so wide tacked along one edge, and a similar cleat tacked at one end so as to project at right

angles 7 cms. from the first cleat. Two similar cleats are fastened together at right angles by cutting their ends off at an angle of 45 degrees and tacking them to a piece of wood at the corner so that the lower surfaces of the cleats are in the same plane. The dirty slides are placed side by side along the cleat fastened to the base board, and the detached right angle piece set upon the board so as to hold the slides in place. By exercising some little pressure against the side and end of the slides, the device may be turned upside down without the slides falling out of place. The slides thus held firm are scrubbed with soap (sapolio) and water, the slides turned and their other sides cleaned in a similar manner. Time may be saved in the turning of the slides by having a second base board provided with cleats as above described, placing it over the slides and inverting. The slides will thus be transferred to the second board with their unscrubbed surfaces uppermost. After these have been cleaned, the slides are thoroughly rinsed in water, it being advantageous to invert them once or twice by transferring them from one board to another. The slides may be rapidly dried as follows, the glass being also left in a clean, highly lustrous state: A coil of spring brass wire, about 2 cm. in diameter and 10 to 12 cms. long, is prepared (the spiral springs used to hold a collection of penholders answers, if the wire be stiff enough) and the ends of the slides inserted firmly between the consecutive coils. The slides and coil are then soused in clean alcohol contained in a wide, shallow jar or dish and hung up to dry.

Correspondence.

EDITOR SCHOOL SCIENCE:

The words of Dr. Ingerson in the November number (page 291) ought, in my opinion, to be taken very seriously to heart by every true physics teacher, and much thought given to ways of remedying the evils there arraigned. Electricity and magnetism are, it is true, fascinating subjects to the average pupil, and his interest is aroused by coming into more direct contact with things about which he has been more or less curious from his early grammar-school days. But, as Dr. Ingerson says, "we need to have a care lest our class-rooms degenerate from places of education into halls of diversion and amusement." The culling out of the hard things in the study of elementary physics, the avoiding of everything that is dry and distasteful to the pupil is a practice which seems to be on the increase, and it is high time that a halt is called. The mere acquisition of facts is not what the study of physics should require of the learner—that is perhaps the last of its requirements. What physics should give is power—power to think, to do, to act.

A young man presented a note-book on physics as one of his credentials for entrance into a university. It was neatly written and showed that the candidate had considerable ability in observation and facility of

expression. The contents pertained almost wholly to the subjects of electricity and light. On examination, the candidate for admission showed an almost total lack of comprehension of the simplest notions of mechanics. He had, indeed, made an induction coil and a telescope, but the power acquired thereby had been rather that pertaining to the artisan than to the scientist. His work in physics had resulted in comparatively little benefit to himself, although he professed great interest in the subject. The fault did not lie with him, but did lie with his teacher. What is to be done with cases like this, which are by no means uncommon?

The bother about the study of elementary physics is that the hard things come first. In a year's course the fundamental subject of mechanics takes up, or at least should take up, the first four months. Teachers are prone to avoid this *absolutely necessary* work in mechanics, or at least to slight it. And yet it is fundamental to the whole science. A good grasp of the principles of mechanics once obtained and the rest of the work is comparatively easy. Pupils, it is true, get a distaste, perhaps, for the whole of physics from the preliminary part of it, but is it good pedagogics or good science to avoid the distasteful things? Keep the pupils' anticipation agog as to the interesting things that are to come after the drudgery. Geometry is distasteful to most students at first, but still they learn it, and in the good old way.

Is mechanics harder than geometry? I think not, and pupils can be led to get even more interest out of it than out of geometry. Do not cut out as much as possible of mechanics but rather increase its amount for the profit to the student will be that much the greater.

The *practical* facts of geometry are commonly known by students before they study geometry, and yet they plod away at the subject for a year and why? The only answer is, to acquire power. And so it should be with physics. Make physics a "powerful" study.

X

QUESTIONS FOR DISCUSSION.

Teachers are invited to send in questions for discussion, as well as answers to the questions of others. Those of sufficient merit and interest will be published.

36. What is a good list of about a dozen quantitative experiments suitable for a class in high school chemistry?

37. What cases of chemical arithmetic should a senior class in high school be required to master?

38. Which is considered to be of more pedagogical value, a half year of botany or a half year of physiography?